Contents

Chairman's Comments 1

Polycrystalline Thin Films – Introduction

Silicon float-zoned crystal growth for high minority charge-carrier lifetime material applications 5
T. F. Ciszek (Golden, CO, U.S.A.)

Recent amorphous silicon research results at the Solar Energy Research Institute. 15
R. S. Crandall, Y. S. Tsuo, Y. Xu, A. H. Mahan and D. L. Williamson (Golden, CO, U.S.A.)

Thoughts on the microstructure of polycrystalline thin film $CuInSe_2$ and its impact on material and device performance 21
J. R. Tuttle, D. S. Albin and R. Noufi (Golden, CO, U.S.A.)

Regular Papers

The phase behavior of evaporated copper and indium precursors for selenization 41
D. S. Albin, G. D. Mooney, J. Carapella, A. Duda, J. Tuttle, R. Matson and R. Noufi (Golden, CO, U.S.A.)

Enhanced grain growth in polycrystalline $CuInSe_2$ using rapid thermal processing 47
D. S. Albin, G. D. Mooney, A. Duda, J. Tuttle, R. Matson and R. Noufi (Golden, CO, U.S.A.)

Surface passivation of polycrystalline, chalcogenide based photovoltaic cells. . . . 53
D. Cahen (Rehovot, Israel) and R. Noufi (Golden, CO, U.S.A.)

Advances in $CuInSe_2$ and CdTe thin film solar cells. 61
W. N. Shafarman, R. W. Birkmire, D. A. Fardig, B. E. McCandless, A. Mondal, J. E. Phillips and R. D. Varrin, Jr. (Newark, DE, U.S.A.)

The formation of $CuInSe_2$ thin films by rapid thermal processing 69
G. D. Mooney, A. M. Hermann (Boulder, CO, U.S.A.), J. R. Tuttle, D. S. Albin and R. Noufi (Golden, CO, U.S.A.)

Fabrication of CdTe solar cells by laser-driven physical vapor deposition 79
A. Compaan, A. Bhat, C. Tabory, S. Liu, M. Nguyen, A. Aydinli, L.-H. Tsien and R. G. Bohn (Toledo, OH, U.S.A.)

Environmental, health and safety issues associated with the manufacture and use of II–VI photovoltaic devices 89
P. D. Moskowitz and V. M. Fthenakis (Upton, NY, U.S.A.)

Annealing effects on individual loss mechanisms in $CuInSe_2$ solar cells 101
R. A. Sasala and J. R. Sites (Fort Collins, CO, U.S.A.)

Growth and process optimization of CdTe and CdZnTe polycrystalline films for high efficiency solar cells. 109
A. Rohatgi, R. Sudharsanan, S. A. Ringel and M. H. MacDougal (Atlanta, GA, U.S.A.)

Thin films of II–VI compounds and alloys 123
T. L. Chu, S. S. Chu, C. Ferekides, J. Britt, C. Q. Wu, G. Chen and N. Schultz (Tampa, FL, U.S.A.)

Elsevier Sequoia/Printed in The Netherlands

$CuInSe_2$ photovoltaic modules. 131
K. W. Mitchell, W. Chesarek, D. R. Willett, C. Eberspacher, J. H. Ermer and R. R. Gay (Camarillo, CA, U.S.A.)

Cadmium telluride module development 137
S. P. Albright, R. R. Chamberlin and J. F. Jordan (El Paso, TX, U.S.A.)

Preparation of Cd(Zn)Te and $CuInSe_2$ films and devices by a two-stage process 143
B. M. Basol and V. K. Kapur (Inglewood, CA, U.S.A.)

Characterization of the defect levels in copper indium diselenide 151
F. A. Abou-Elfotouh, H. Moutinho, A. Bakry, T. J. Coutts and L. L. Kazmerski (Golden, CO, U.S.A.)

Amorphous — Introduction

Non-linear recombination processes in photovoltaic semiconductors. 163
R. K. Ahrenkiel, B. M. Keyes and D. J. Dunlavy (Golden, CO, U.S.A.)

What can we learn from the saturation of light-induced defects in amorphous hydrogenated silicon? 177
M. Isomura, X. Xu and S. Wagner (Princeton, NJ, U.S.A.)

Regular Papers

Needs of the amorphous silicon program with respect to stabilized module performance 195
W. Luft, B. Stafford and B. von Roedern (Golden, CO, U.S.A.)

Distribution of the density of states of bonded hydrogen in amorphous hydrogenated silicon 207
R. A. Street (Palo Alto, CA, U.S.A.)

Electroluminescence studies of recombination in hydrogenated amorphous silicon p–i–n devices 219
K. Wang, D. Han, M. Silver (Chapel Hill, NC, U.S.A.) and H. M. Branz (Golden, CO, U.S.A.)

Photocarrier drift measurements and solar cell models for amorphous silicon 227
E. A. Schiff (Syracuse, NY, U.S.A.)

Defect equilibration and metastability in low-spin-density amorphous hydrogenated silicon 235
T. J. McMahon (Golden, CO, U.S.A.)

Structural, optical, and electrical studies of amorphous hydrogenated germanium 245
W. A. Turner, S. J. Jones, Y. M. Li, D. Pang, A. E. Wetsel and W. Paul (Cambridge, MA, U.S.A.)

Hydrogen content and the goal of stable efficient amorphous-silicon-based solar cells 255
C. M. Fortmann, S. S. Hegedus, T. X. Zhou and B. N. Baron (Newark, DE, U.S.A.)

Progress on high performance multijunction amorphous hydrogenated silicon alloy based solar cells and modules 261
A. Catalano, R. R. Arya, M. Bennett, L. Yang, Y. Li, B. Fieselmann, S. Wiedeman and J. Newton, J. Morris, K. Rajan, G. Wood, C. Poplawski and B. Goldstein (Newtown, PA, U.S.A.)

High-deposition-rate amorphous silicon solar cells: silane or disilane? 271
D. S. Shen, H. Chatham and P. K. Bhat (Golden, CO, U.S.A.)

Overview of amorphous silicon photovoltaic module development 277
D. E. Carlson (Newtown, PA, U.S.A.)

Advances in double-junction amorphous silicon photovoltaic modules. 285
Y. Ichikawa and H. Sakai (Kanagawa, Japan)

The effects of impurities on the light-induced degradation of hydrogenated amorphous silicon 293
J. D. Cohen and T. Unold (Eugene, OR, U.S.A.)

Crystalline

Materials aspects of multijunction solar cells 305
S. A. Hussien, P. Colter, A. Dip, J. R. Gong, M. U. Erdogan and S. M. Bedair (Raleigh, NC, U.S.A.)

Review of the application of molecular beam epitaxy for high efficiency solar cell research 313
M. R. Mellopch (West Lafayette, IN, U.S.A.)

A novel reactor for large-area epitaxial solar cell materials. 323
P. B. Chinoy, D. A. Kaminski and S. K. Ghandhi (Troy, NY, U.S.A.)

Thin film approaches for high-efficiency III–V cells 337
G. Lush and M. Lundstrom (West Lafayette, IN, U.S.A.)

Advances in the development of an AlGaAs/GaAs cascade solar cell using a patterned germanium tunnel interconnect 345
R. Venkatasubramanian, M. L. Timmons, T. S. Colpitts and J. S. Hills (Research Triangle Park, NC, U.S.A.)

Tandem gallium solar cell voltage-matched circuit performance projections. 355
L. M. Fraas, J. E. Avery, P. E. Gruenbaum, R. J. Ballantyne and E. Malocsay (Seattle, WA, U.S.A.)

High-performance concentrator tandem solar cells based on IR-sensitive bottom cells 363
M. W. Wanlass, J. S. Ward, K. A. Emery, T. A. Gessert, C. R. Osterwald and T. J. Coutts (Golden, CO, U.S.A.)

Silicon solar cell materials research: current progress and future needs 373
B. L. Sopori (Golden, CO, U.S.A.)

Solarex experience with ethylene vinyl acetate encapsulation 383
J. H. Wohlgemuth and R. C. Petersen (Frederick, MD, U.S.A.)

Alternative Growth Techniques

Electron cyclotron resonance microwave plasma deposition of a-Si:H and a-SiC:H films 391
Y. H. Shing and F. S. Pool (Pasadena, CA, U.S.A.)

Crystallized amorphous silicon for low-cost solar cells 403
J. Yi, R. Wallace, N. Sridhar, Z. Wang, K. Xie, D. D. L. Chung, C. R. Wie, K. Etemadi and W. A. Anderson (Amherst, NY, U.S.A.), M. Périard, R. W. Cochrane, Y. Diawara, J. F. Currie (Montreal, Que., Canada) and J. Coleman (Locust Valley, NY, U.S.A.)

Low temperature homoepitaxial growth of GaAs by dissociating trimethylgallium and trimethylarsenic in a remote hydrogen plasma 415
B. G. Pihlstrom, L. R. Thompson and G. J. Collins (Fort Collins, CO, U.S.A.)

Deposition of μc-Si and μc-Si–C thin films by remote plasma-enhanced chemical-vapor deposition. 419
G. Lucovsky, C. Wang, R. J. Nemanich and M. J. Williams (Raleigh, NC, U.S.A.)

Windows, Contacts and Doping

Textured fluorine-doped ZnO films by atmospheric pressure chemical vapor deposition and their use in amorphous silicon solar cells 437
J. Hu and R. G. Gordon (Cambridge, MA, U.S.A.)

Cu/In deposited at room temperature: morphology, phases and reactions 451
J. S. Chen, E. Kolawa, M.-A. Nicolet and R. P. Ruiz (Pasadena, CA, U.S.A.)

Practical guidelines for grid metallization in photovoltaic solar cell research 459
T. A. Gessert, X. Li and T. J. Coutts (Golden, CO, U.S.A.)

Broad band spectroscopic ellipsometry for the characterization of photovoltaic materials 473
F. A. Abou-Elfotouh, G. S. Horner, T. J. Coutts and M. W. Wanlass (Golden, CO, U.S.A.)

Solar Radiation, Simulation and Applications

Solar radiation research for photovoltaic applications. 489
C. Riordan, R. Hulstrom, T. Cannon and D. Myers (Golden, CO, U.S.A.)

The difference between standard and average efficiencies of multijunction compared with single-junction concentrator cells 501
S. R. Kurtz, J. M. Olson and P. Faine (Golden, CO, U.S.A.)

Cost and performance sensitivity studies for solar photovoltaic/electrolytic hydrogen systems 515
J. M. Ogden (Princeton, NJ, U.S.A.)

Photovoltaic Module Reliability Workshop

Preface 527

Early experiences of the 15 kW NMPC demand-side management photovoltaic project 529
B. Bailey, R. Perez, J. Doty, K. Elsholz, R. Stewart (Albany, NY, U.S.A.) and W. Huse (Syracuse, NY, U.S.A.)

Three-year performance and reliability analysis of a 4 kW amorphous–silicon photovoltaic system in Michigan 535
R. G. Pratt (Detroit, MI, U.S.A.)

$CuInSe_2$ module environmental reliability 549
D. E. Tarrant, R. R. Gay, J. J. Hummel, C. Jensen and A. R. Ramos (Camarillo, CA, U.S.A.)

Reliability studies of Eureka modules 559
J. Grez, J. Kolesar and F. Kampas (Princeton, NJ, U.S.A.)

Field test results for the 6 MW Carrizo Solar Photovoltaic Power Plant 563
A. L. Rosenthal and C. G. Lane (Las Cruces, NM, U.S.A.)

Author Index 573

Subject Index 575